IMPERIAL COLLEGE LONDON

TIMED REMOTE ASSESSMENTS 2021-2022

MSc Computing
for Internal Students of the Imperial College of Science, Technology and Medicine

PAPER COMP70036=COMP97074

OBJECT ORIENTED DESIGN AND PROGRAMMING

Monday 9 May 2022, 10:00
Writing time: 90 minutes
Upload time: 10 minutes

Answer ALL TWO questions
Open book assessment

Paper contains 2 questions

1   Your task is to develop a simulation of a (simplified) traffic system.

a   Implement a data model for the traffic system according to the following requirements:

– A road segment is the connection between two intersections
– Road segments have a (integer) length and a maximum speed that vehicles can go when traveling on the road segment (also an integer).
– Speed is measured in meters per second.
– The length of road segments is measured in meters
– An intersection connects no more than four road segments (this is, obviously simplified)
– Intersections have no length/size (another simplification)
– Every road segment ends in an intersection (the traffic system has no dead-ends)
– Vehicles travel along road segments
– Vehicles have a travel speed (an integer)
– All vehicles are exactly one meter long and can only be at an integral distance from the start of a road segment. For example, a vehicle can be at 4 meters from the beginning of the road segment, but not at 4.3 meters. The maximum number of vehicles on any road segment is, therefore, equal to the length of the road segment.

You shall define the classes, select appropriate types for the data members as well as constructors. You may omit the definition of getters and setters in favor of directly accessing the data members. Implement your solution in `answer1.cpp`.

b   Implement the following behavior:

– The road segments shall implement a function called `moveTimeForward()` that progresses the simulation by one second. When it is called two things shall happen:
– First, if a car is at the end of a road segment, it shall "take a turn". For that purpose, the car shall (randomly) select a direction to take: left, right or straight (represented by an integer that is, respectively, 0, 1 or 2).
  ∗ If the intersection has a road in that direction, and the beginning of that road is free (no vehicle is currently at 0 meters from the beginning of the road segment), the vehicle shall move to that road segment
  ∗ Otherwise, the vehicle stays in place until the next call to `moveTimeForward()`
– Further, **all** cars on the road segment shall move forward (in any order you choose) according to the following rules: ©

∗ The speed at which the vehicle moves forward is the minimum of the maximum speed of the road segment and the defined speed of the vehicle
∗ The vehicle shall, then, move forward according to the determined speed (e.g., if the speed is 5 m/s, the vehicle moves forwards 5 meters)
∗ **If and only if** another vehicle blocks the way (is anywhere in a position between the position of the vehicle before the move and the position it would move to), the moving vehicle stops right behind the blocking vehicle.

You may *not use* any templates

The two parts carry, respectively, 40% and 60% of the marks.

2   Consider the following scenario:

- One of the measures to combat a global disease caused by a virus is comprehensive virus testing of the population. Health professionals can administer two types of virus tests: a serology test, which detects an immune response to the virus, and a PCR (polymerase chain reaction) test, which detects the presence of a virus.

- Both types of tests have a cost. A serology test has a fixed cost of £50 but PCR tests have different costs (depending on different suppliers, laboratories, etc but this is not relevant for this scenario). While serology tests are only available as a test-only offering, PCR tests are offered as test-only but with the option to also sequence the variant of a virus, which doubles the cost of the PCR test regardless of whether a virus was found or not.

- There are two types of health professionals who administer virus tests, nurses and pharmacists. They have a name, a record of number of years of work experience, and are paid a yearly base salary (in pounds). They individually record all virus tests they administer in a year because their actual yearly salary is based on the total costs of these tests and is calculated by the following formula:

$$salary_{nurse} = base\_salary + 100 * work\_experience + 0.2 * total\_test\_costs$$
$$salary_{pharmacist} = base\_salary + 100 * work\_experience + 0.1 * total\_test\_costs$$

Nurses and pharmacists can calculate their actual yearly salary at any time.

a   Write C++ class declarations and definitions to support the scenario above in the file *answer2.cpp*. Salaries and virus tests for multiple years do not need to be considered. You must use the given class template *list* if you need a sequential container, for which the available member declarations can be found in the provided skeleton file *answer2.cpp*.

b   Add a test function to *answer2.cpp* that does the following:

   – Creates two health professionals: a nurse called *Paula* who receives a base salary of £20000 and who has 5 years of work experience; a pharmacist called *Sara* who receives a base salary of £25000 and who has 10 years of work experience.

   – Creates 3 virus tests: one PCR test (pcr1) that costs £90, another PCR test (pcr2) that costs £150 and a serology test.

   – The nurse administers the pcr1 test (test-only) and the serology test. She records that she has administered these two tests. The pharmacist performs the pcr2 test adding the option to sequence variants and adds this to her record.

   – Prints the actual yearly salary for both health professionals.

The two parts carry, respectively, 80% and 20% of the marks.